Opening Learning Opportunities with Open Educational Resources and Practices: A Taste of MERLOT and Virtual Labs

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Abstract

As the COVID-19 pandemic and safer-at-home mandates continue, educational systems around the world strategize on-going student engagement via virtual instruction. Faculty navigate the virtual learning space with a range of experiences, from having taught informal, conversational lectures for decades to being able to flip the classroom. The conversion to an online learning environment over the last several months presents a wide array of challenges, including teaching laboratory courses, academic integrity issues such as cheating on examinations and plagiarism, equitable computing and Wi-Fi access, affordability of course materials, and housing with a quiet place to work and study. Moving the teaching and learning of chemistry online is a complex process and success in this endeavor will take more than what we at MERLOT can review in this article, though we believe we can provide significant support for faculty and institutions. The goal of this article is to provide the chemistry education community free, online, and easy-to-use resources and services that can help individuals, departments, and institutions move to blended and online modes of instruction successfully. We will also provide a case study of teaching with virtual labs with evidence of its positive impact on students' learning.

Exploring Open Educational Practices

While Open Educational Resources (OER) and virtual labs can be essential ingredients for moving chemistry courses online and engaging students with affordable online resources, faculty also need to explore exemplary practices for using these technologies as they redesign their courses. Openly sharing the teaching "know how" is critical if faculty are to use OER effectively so students learn successfully. To support the sharing of instructional "know how", MERLOT has an Open Educational Practices portal that provides collections of teaching ePortfolios that capture the voices of faculty teaching their courses and explaining how their strategies using technology affected student learning and success. The OER portal features 70 free and open teaching ePortfolios by Cal State University chemistry faculty openly sharing their strategies for redesigning their chemistry courses with technology and innovative pedagogies. For those considering flipping the classroom, using supplemental instruction, or project based learning, these educational practices are freely and transparently captured and shared in the open teaching ePortfolios. MERLOT has a specific collection of teaching ePortfolios for chemistry faculty sharing their implementation of virtual labs in their courses. These ePortfolios have a consistent structure that provide the background on the course, the challenges students were having learning successfully, the characteristics of the students, the description of their instructional innovation, and often longitudinal data about the impact of the instructional innovation of student learning and success. Looking to substitute a free and open etextbook in Chemistry and wondering how others have done it? Explore the free and open teaching ePortfolios by STEM faculty where you can also download the faculty's course syllabus to see the details for using the free etextbook in their course.

Sharing Your Educational Resources and Practices

MERLOT is not only a free and open library to discover and adopt free online teaching resources and practices but it is also a library for educators to contribute their OER and "know how" (Open Educational Practices) for free as well. How has the MERLOT collection been created? MERLOT enables registered members to catalog resources that they have found useful. Educators, students, instructional designers, librarians, academic staff, and more have been contributing materials to the library for over 23 years and community-based processes continue today. MERLOT membership is free and open to everyone. Over 1,000 people join as members every month and many of them collectively contribute over 250 resources every month. Faculty can not only catalog free and open educational resources in MERLOT so others can easily discover them but they can add learning assignments for using the OER. Faculty can also have their students explore the MERLOT collection as well as identify and comment on materials that they have found helpful for their learning. MERLOT can be your students' free learning library. MERLOT provides its registered members the tools to create their own personal "bookshelves" for collecting and sharing the resources they find most useful. MERLOT has a YouTube channel that provides video instructions for accomplishing all these goals.

Authoring OER with MERLOT Content Builder

Almost all the teaching ePortfolios in the Open Educational Practices portal were created with MERLOT's free and open website authoring tool, Content Builder. As a MERLOT registered member (registration is free), you can create your own ePortfolios using the easy-to-use website templates MERLOT provides its members. You can give voice to your "know how" of teaching with technology, enabling others to benefit from your expertise. The MERLOT Content Builder tool can also be used to create OER websites and portals to help your institution learn to move teaching and learning online. We have created a template portal and many derivative portals were created by rebranding and editing the template for different institutions.

In summary, MERLOT's free and open educational resources and services can provide the chemistry education community with immediately available tools and technologies to help faculty and students teach and learn chemistry with greater success. The next section will be a case study of a Cal State University Long Beach faculty using virtual labs in her course and will include evidence of the impact on student learning.

Finding Free Online Instructional Resources for Chemistry

Some of the essential ingredients for successful online instruction are the quality online content that is used in the teaching and learning of chemistry. Finding quality, affordable, and pedagogically sound teaching materials can be a challenge. For over the last 23 years, MERLOT has provided a free and open library of online teaching and learning resources collected by education communities. MERLOT provides a suite of open educational resources and services for helping faculty and institutions put educational innovations into practice (Schneebeck & Hanley 2001, Hanley 2006, 2014, 2015). MERLOT has a Chemistry Community and Editorial Board, which curates its quality collection and provides easy access to a range of over 4,000 free online teaching and learning materials that have been organized by subdisciplines within chemistry.

Exploring Free Virtual Labs In Chemistry

MERLOT also organized the different types of materials that are aligned with different types of learning experiences, from animations, to assessment tools to online courses and course modules to free and open etextbooks, simulations, and tutorials. MERLOT has curated a collection of "virtual labs" in its Virtual Labs portal which provides easy access to virtual labs in chemistry as well as other STEM disciplines. Adopting virtual labs can be an essential strategy for optimizing campus laboratory space by scheduling virtual labs and wet labs within the semester. By alternatively sharing space, campuses will be able to support social distancing requirements by enabling half the students performing on-campus labs while the other half of the students are completing virtual labs in their own safe environments . The Cal State University conducted a study of the impact of blended and fully online biology labs and produced evidence of a number of important outcomes. As will be discussed subsequently in the following case study, the benefits of engaging students and supporting the visualization of chemistry can enhance learning outcomes and appreciation of chemistry (Alekseev, Hanley, Kiyasov,Platonov 2018).

Virtual Labs In Chemistry: A Case Study

One of the resources available via MERLOT is the Physics Education Technology (PhET) simulation platform. PhET is a low-bandwidth yet highly interactive resource that students can easily access through their desktop or mobile device, and PhET simulations covering a wide variety of STEM disciplines are available and curated through MERLOT.

CHEM 100, Chemistry in Today's World, is a course at CSULB for non-science majors and provides a chemical context for sustainability initiatives and issues at the local, national, and global community. CHEM 100 includes basic principles of chemistry and a consideration of the benefits and problems arising from applications of chemistry. The course also encompasses discussions of foods and food additives, drugs, plastics, and other materials of everyday life, fuel sources, the atmosphere, and freshwater. Since 2014 the course has been developed to be more practical and engaging, and adapted to use mobile and web apps to teach concepts that can be a challenge to visualize. PhET is currently used in CHEM 100 to span several topics including VSEPR, acid-base chemistry, subatomic particles, and energy transfer.

PhET lends very well to instructors who aim to use visual and kinesthetic teaching strategies. The visualization and interactivity that PhET provides allows my students and I to talk through some of the most challenging concepts and create meaningful learning experiences. Two of my favorite activities are “Acid-Base Solutions” and “Energy Forms and Changes” simulations. In the acid-base chemistry simulation, students get a physical sense of how acids and bases dissociate, and the extent in which the dissociation is related to pH changes and weak versus strong electrolytes. In the energy transfer simulation, students explore the different types of energy and give examples from everyday life, articulate how energy can change from one form of energy into another and explain the conservation of energy in real-life systems. In regards to lesson planning, the acid-base solution simulation is assigned first, then the energy transfer simulation, and this sequence builds a foundation for teaching galvanic and electrolytic cells.

Anecdotally, students have shared that PhET resources help them make sense of content, and changes the pace from multiple choice, traditional online homework platforms. I had not formally assessed how educational technology integration strategies support student learning, so I chose the Colorado Learning Attitudes about Science Survey (CLASS) for chemistry, which is part of the PhET and the Physics Education Research Group at Colorado (PER@C). The CLASS-Chem survey takes a look at how student beliefs and perceptions about chemistry are shaped through classroom experience. The survey has fifty questions and is based on a seven-point Likert scale, in which responders specify their level of agreement in seven points: (1) Strongly disagree; (2) Somewhat Disagree; (3) Disagree; (4) Neither agree nor disagree; (5) Somewhat Agree; (6) Agree; and (7) Strongly agree. The survey was administered at the beginning and the end of the Spring 2019 semester. The total enrollment for CHEM 100 was 178 students. The pre-survey response rate was 97% and the post-survey response rate was 48%. A paired t-test was used to determine significant changes among survey items.

Table 1
CSULB CHEM 100 CLASS Survey T-Test Results

Survey Item	Pre	Post	Pre to Post change	p value
“A significant problem in learning chemistry is being able to memorize all the information I need to know.”	5.254	4.395	-0.858	0.00
“I think about the chemistry I experience in everyday life.”	3.151	4.082	0.931	0.00
“I think about how the atoms are arranged in a molecule to help my understanding of its behavior in chemical reactions.”	4.151	4.788	0.637	0.02
“I cannot learn chemistry if the teacher does not explain things well in class.”	6.047	5.494	-0.553	0.00
“I can usually make sense of how two chemicals react with one another.”	4.256	4.671	0.415	0.03
“To understand chemistry I discuss it with friends and other students.”	4.639	5.214	0.575	0.01
“I do not spend more than five minutes stuck on a chemistry problem before giving up or seeking help from someone else.”	3.628	4.012	0.384	0.04
“In doing a chemistry problem, if my calculation gives a result very different from what I'd expect, I'd trust the calculation rather than going back through the problem.”	2.988	3.565	0.576	0.00
“In chemistry, it is important for me to make sense out of formulas before I can use them correctly.”	5.686	5.226	-0.460	0.00
“When I see a chemical formula, I try to picture how the atoms are arranged and connected.”	3.872	4.262	0.400	0.02
“The arrangement of the atoms in a molecule determines its behavior in chemical reactions.”	5.047	5.388	0.342	0.05
“I can usually figure out a way to solve chemistry problems.”	4.360	4.774	0.413	0.03
“When I'm solving chemistry problems, I often don't really understand what I am doing.”	4.244	3.494	-0.750	0.01

The results suggest that students are able to problem solve, visualize, and work with others regarding course content. The significant increase in, “I can usually figure out a way to solve chemistry problems,” and the significant decreases in the items, “A significant problem in learning chemistry is being able to memorize all the information I need to know” and “When I'm solving chemistry problems, I often don't really understand what I am doing” suggest that students are able to make sense of what they are learning without relying on memorization and are confident about their understanding of chemistry. Further, students feel comfortable working with other students and discussing chemistry problems as demonstrated by significant increases in the items, “To understand chemistry I discuss it with friends and other students, ” and, “I do not spend more than five minutes stuck on a chemistry problem before giving up or seeking help from someone else.” Students were able to connect atomic and molecular behavior to chemical reactivity as shown by significant increases in items, “I think about how the atoms are arranged in a molecule to help my understanding of its behavior in chemical reactions,” “I can usually make sense of how two chemicals react with one another,” “When I see a chemical formula, I try to picture how the atoms are arranged and connected,” and “The arrangement of the atoms in a molecule determines its behavior in chemical reactions.”

Results that need further clarity would be the significant increase for, “In doing a chemistry problem, if my calculation gives a result very different from what I'd expect, I'd trust the calculation rather than going back through the problem,” and the significant decrease for, “In chemistry, it is important for me to make sense out of formulas before I can use them correctly.” Regarding calculations, CHEM 100 students focus on basic algebra, which includes balancing oxidation numbers (or ionic charges) to write appropriate chemical formulas, and stoichiometry. My current thinking is that students perhaps feel confident in being able to accurately calculate with support or feedback from peers, which may reduce the need for self-checking. The significant increase on the items, “I think about how the atoms are arranged in a molecule to help my understanding of its behavior in chemical reactions,” “I can usually make sense of how two chemicals react with one another,” “When I see a chemical formula, I try to picture how the atoms are arranged and connected,” and “The arrangement of the atoms in a molecule determines its behavior in chemical reactions,” suggests that students think of atoms and molecules as dynamic rather than static.

What I was most excited about in the results was the significant increase for the item, “I think about the chemistry I experience in everyday life,” which is one of the primary objectives of CHEM 100. What using a platform like PhET has allowed me to do is dedicate more time to discussing the connections between sustainability and chemistry. For example, since students can get a better sense of VSEPR more efficiently and effectively, then that allows me time and space to discuss the relationship between molecular structures and the infrared absorption of greenhouse gases due to asymmetrical stretching modes. Having a stronger foundation of acid-base chemistry, energy transformation, and ultimately batteries, I can then discuss the sustainability and environmental impact of materials used for battery manufacturing.

Conclusion

MERLOT is a community of educators that openly share online resources and educational practices and we invite you to join, participate,and benefit from being a

MERLOT member. Being a part of an international community of chemistry educators gives the opportunity to review, develop, and co-create engaging virtual learning experiences that are contextualized in a time of global pandemic. MERLOT's Chemistry Editorial Board is open to new members and training to be a peer reviewer through MERLOT's online "GRAPE Camp" will be offered. Contact Elaine Villanueva Bernal, the Editor of the Chemistry Editorial Board, for further information. Together we can help grow the community of students, faculty, and staff who enthusiastically and successfully develop skilled chemists and professionals who enjoy the productive use of chemistry to improve the well-being of people.

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